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RECORD OF REVISION

Rev	Date	Description	POC	OIC
0	09/16/01	Initial Issue.	Tobin H. Oruch, <i>FWO-SEM</i>	Mitch S. Harris, <i>FWO-SEM</i>
1	6/9/04	Added requirements for programmatic; updated references. Replaces former Section 310 of LEM (now ESM).	Charles DuPrè, <i>FWO-DECS</i>	Gurinder Grewal, <i>FWO-DO</i>

D10-30PFD PFD AND P&ID DIAGRAMS (PROGRAMMATIC & FACILITY)

1.0 GENERAL

- A. This section defines the requirements for Process Flow Diagrams (PFDs) and Piping and Instrumentation Diagrams (P&IDs) for LANL systems.
- B. See ESM Chapter 1 Section Z10 and Chapter 6 Section D10-30GEN for additional requirements.
- C. P&IDs and PFDs meeting the requirements of this document are required for material handling/processing, piping, and HVAC systems when any of the following are true:
 - 1. The systems are safety-related systems (definition per Z10).
 - 2. When they have been designated as Priority Drawings per LANL LIR240-01-01, Facility Configuration Management.
- D. *Guidance: P&IDs and PFDs are recommended for all complex mechanical systems.*
- E. Use this section in conjunction with the LANL Drafting Manual for the development of complete drawings.
- F. P&ID definitions are included in Attachment 1, Glossary, to this section.

2.0 OVERVIEW (GUIDANCE)

- A. *PFDs depict a given system's flows, temperatures, pressures and mass balances for various operating conditions. Such information is typically presented in the form of tables on the PFDs. PFDs present functional information about a system or subsystem. Components such as piping, pumps, and valves are represented by standard schematic symbols that illustrate their function in the system, as opposed to their relative sizes, locations, or physical shapes. Instrumentation and control information is not included.*

PFDs are typically the first drawings developed for a mechanical process, often in the preconceptual or conceptual design phase.

- B. *P&IDs are typically developed from PFDs. P&IDs communicate detailed information on how to operate, troubleshoot, and repair or modify a system or subsystem. In addition to the mechanical components, they include instruments, signal modifiers, controllers, and their inter-relationships. They typically do not include tabular parameters as PFDs do.*

Terms associated with P&IDs are defined in Attachment 1 to this section.

When PFDs are drawn carefully, P&IDs can be produced as additional CAD layers added to the PFD.

- C. *PFDs and P&IDs are almost always limited to a specific system, and show supporting or interfacing components of other systems only to the extent necessary to allow the reader to understand the relevant interrelationships. The primary purpose of the P&ID is to bring together system information from various engineering disciplines (mechanical, electrical, control/instrumentation, et al) and present it in one drawing or drawing set to illustrate how a system works as a whole.*
- D. *As a rule, PFDs and P&IDs do not have a drawing scale and usually present only the functional relationship or sequence of components. Two pieces of equipment that appear next to each other on the PFD or P&ID may not even be in the same building. Two pumps with widely different flow and pressure characteristics may be represented by similar symbols. Piping bends and relative lengths may or may not reflect the actual, as-built geometry in the field. In general, PFDs and P&IDs only present information on how a system functions, not the relative physical locations or spatial relationships.*
- E. *PFDs and P&IDs are done in a “single line” format that represents all piping and ductwork as a single line regardless of size. Differences in piping function (e.g., primary flow, secondary flow, instrumentation, electrical, etc.) are indicated by varying the width or characteristics of the line. Pipe sizes are shown with text alongside the line.*
- F. *The most common symbols used in PFDs and P&IDs are defined in ESM Chapter 6 Standard Detail ST6999, Symbols, Process Flow and P&IDs. If a user or drafter encounters a component not covered in ST6999, one should refer to the reference subsection of this document for standards that contain additional, industry-accepted guidance. Creating unique symbols is highly discouraged, although situations may arise which are not covered in these publications. In that case, the designer should clearly define all symbols used in the drawing legend (begin with ST6999 and create a new project-specific legend sheet, adding to ST6999 symbols as needed).*
- G. *ESM example diagrams are shown by the following attached drawings:*
 - *Ventilation System PFD: M-6010*
 - *Ventilation System P&ID: M-6030*
 - *Cooling Tower System PFD: M-6020*
 - *Cooling Tower System P&ID: M-6040 through M-6042*

3.0 FORMAT AND SYMBOLS

A. Format

1. *PFDs and P&ID size, format, drafting layers, and software shall be in accordance with the LANL Drafting Manual. PFDs shall be formatted as depicted in attached example drawings M-6010 and M-6020. P&IDs shall be formatted as depicted in M-6030 and M-6040 - 6042.*
2. *Guidance: PFDs and P&IDs should be specific to one system only (e.g., HVAC, Compressed Air, Tower Water, etc). Put another way, apart from system interfaces, no more than one system should be shown on a single diagram. See the approved system list Section 210 of LANL Engineering Manual Chapter 1, and the discussion of system boundaries in Section 220.*

3. *Guidance: PFDs and P&ID should be configured such that major flow paths are shown from left to right and top to bottom, if possible. Primary flow paths should not suffer major changes in direction on the PFD or P&ID.*

B. Drawing Symbols

1. PFD and P&ID drawing symbols shall be in accordance with the standard legend and symbols provided in ST6999. *When producing drawings, refer to the LANL Drafting Manual's Mechanical Drawings section and its related Appendix contains symbol files.*
2. Examples M-6010 - 6042 shall be followed for the consistent layout and application of symbols. If not reflected in these referenced drawings, ISA-5.1, *Instrumentation Symbols and Identification*, shall be applied to the maximum extent possible.
3. Component numbering shall be as described by LANL Engineering Standards Manual Chapter 1, Section 230.

4.0 TECHNICAL DETAIL

NOTE on Setpoints: The Project Manager shall indicate where setpoints are to be controlled. If setpoints are documented by computer, database, or controlled list (preferred methods), then they shall not be repeated on drawings. However, the PM may direct that setpoints be on the drawings (e.g, P&IDs) vice a database or list.

A. General Guidance:

1. *Equipment, process flow paths, and interface nodes should be laid out to conform with the sequence of process flow and branching.*
2. *The physical arrangements or characteristics of tanks should be indicated (e.g., instrument connections, penetrations, internal baffles, jackets, spargers, heaters, etc.).*
3. *Each component should be shown only once on a PFD or P&ID sheet or series. If it is necessary for a component to appear on more than one PFD or P&ID, the subsequent appearances should be "ghosted" (shown in light gray color). This occurs most often when two systems are supporting the same component (e.g. heat exchangers).*
4. *If practical, the relative location of equipment (e.g., elevation) should be shown by position on the drawing. Although the main focus of a PFD or P&ID is to present functional information about the system, adhering to this good practice as much as possible makes it easier for drawing users to identify and locate equipment in the field. Additionally, room numbers may be added to clarify equipment and component locations.*
5. *When multiple major process components have identical process, utility piping and instrumentation, only one of the groups with all piping, control and instrumentation may be shown at the discretion of the Project Engineer. The remaining groups should be identified using a block diagram and tables to define valve and instrument numbers (P&ID only).*

6. *For PFDs and P&IDs, the following types of information should be shown, as applicable:*
 - *Mechanical equipment with component ID numbers. If only one system is shown on the drawing, system identifiers can be omitted (see ESM Ch 1, Section 230).*
 - *Main and secondary process lines, ventilation ducts and flow paths, instrument lines, electrical, pneumatic, and mechanical links.*
 - *Local and remote instruments and designations in sufficient detail to delineate the function(s) of the instrumentation and its interface with the process; PFDs should only show instrumentation and controls associated with key control valves or dampers.*
 - *Piping and duct code break boundaries. For example, a system boundary could delineate the break between the HVAC and Compressed Air systems; a piping code break boundary may depict a class break between B31.1 and B31.9 or metal and plastic piping.*
 - *Process valves and dampers including permanently installed high point vent and drain valves (with open and closed indications in their normal positions).*
 - *Permanently installed test connections.*
 - *Floor and wall penetrations (where practical).*
 - *Ductwork identification.*
 - *Glovebox or hood boundaries (only as needed).*
 - *Interconnection reference to other drawings including drawing number and grid coordinates.*
 - *Vendor interface boundary of skid mounted equipment.*
 - *Valve identification, type, actuator type, alignment (e.g., normally open, normally closed, failure state (e.g., fails open, closed), and locked position, as applicable.*
7. *For P&IDs only, the following types of information should be shown, as applicable:*
 - *Equipment Safety Classification boundaries, e.g., Safety-Class, Safety-Significant, etc (optional)*
 - *Instrument switches and relays (devices with the generic description of relays or switches that are actuated by a signal and are part of an instrument loop are classified as instruments; as such, these instruments should be shown on the P&ID, but not PFDs)*
 - *Sequence of operation (optional)*
 - *Tank/wall nozzles with identification*
 - *Heat tracing and type (e.g., steam or electric – include voltage as practical)*
 - *Supplier package piping, valves, instruments and controls to the extent they require operator interface or response*
 - *Status indicating lights*
 - *Annunciation and computer inputs/outputs*
 - *Manual switches and pushbuttons*
8. *The following information should **not** be shown on a PFD or P&ID:*
 - *Electrical power supplies*
 - *Equipment rating and capacity*
 - *Electrical control relays (these non-instrument devices are not actuated by a signal and generally perform a function in the electrical control circuitry)*
 - *Pipe hangers and supports*

- *Supplier package piping which is internal to package and has no operational interface*
- *Standard pipe fittings (except in-line pipe size changes should be shown with a reducer-type symbol)*
- *Valve code*
- *Radiation shielding*
- *Test/Startup boundaries*
- *Extensive explanatory notes*
- *Physical details and dimensions*
- *Site jurisdictional boundaries*
- *Piping connections and type (e.g. threaded, flanged, etc.)*

B. Electrical and Mechanical Equipment Guidance

1. *Three way valves, pneumatic and solenoid actuated valves should be shown in the normal (shelf) state.*

C. Instrumentation Guidance (P&ID only)

1. General

- *All process measurement, process control, and equipment interlock devices that are required to operate, maintain, and control the system equipment should be shown. Illustrate distinctions between local and remote devices, as well as the location and/or panel on which the devices are mounted using appropriate bubbles per ST6999's Instrument/Function Symbols section.*
- *For setpoint requirements see beginning of this Content Subsection (above).*

2. Instrumentation and Control Logic

- *The P&ID should show the field sensing element, the type of input or output, the final indications or selections necessary to be seen on the control room operator's panel, and the presence of an interlock if applicable.*
- *Connection lines that represent a data highway (as shown on the legend sheet) should be used within the digital control system boundary.*
- *A diamond shaped symbol should be used to represent an input to or output from the DCS. Each symbol shall be labeled with an "A" for analog or a "D" for digital. One or more corners of each diamond should be darkened to represent the signal output direction(s). This clearly defines whether a signal is an input or output.*
- *The P&ID interlock symbol may be shown on the same P&ID or make reference to the applicable Control Logic Diagram. The drawing number should be shown at the upper right hand corner of the interlock symbol.*
- *As an alternative, the P&ID may contain a table in the general notes section that lists each loop and logic diagram associated with the interlocks depicted on the P&ID. Each of these drawings should be assigned a corresponding sequential integer beginning with one. The integer should be shown above the upper right hand corner of the interlock symbol referencing the corresponding loop or logic drawing. Generally, analog signal should reference a loop diagram, and digital signal should reference a logic diagram.*
- *All signals involved in an interlock should be shown in a concentrated location on the P&ID. If this is not practical, the use of logic continuations to lead the user to each signal involved in an interlock should be considered.*

- *Valve positioners need not be depicted in complete detail. See ISA 5.1 for options.*

D. Duct and Piping Guidance

1. *The following duct and piping information should be shown:*
 - *Expansion and other flexible joints*
 - *Pipe size changes, e.g., reducers*
 - *Piping and ductwork size*
 - *Flow direction*
 - *Piping material specifications (optional)*
 - *Measuring and restriction orifices.*
 - *Unducted air flow-paths*
 - *Drains, vents, test ports, and other startup and shutdown piping*
2. *Loop seals, siphon breaks, and other pipe configurations that explicitly affect system function should be shown but need not display size annotation.*

5.0 REFERENCES/BASES

1. ISA 5.1 Instrumentation Symbols and Identification (formerly ANSI/ISA S5.1)
2. ISA 51.1, Process Instrumentation Terminology
3. ISA 75 series on control valves
4. ASME Y14.40-2000 series on Graphical Symbols for Diagrams (same as ISO 14617)
5. [DOE-HDBK-1016](#), Engineering Symbols, Prints, and Drawings
6. IEEE Standard 803.1-92 (r2000), Recommended Practice for Unique Identification in Power Plants and Related Facilities - Component Function Identifiers
7. ESM Chapter 6 Drawing ST6999, P&ID Legends, Sheets M-0001 and M-0002
8. LANL Drafting Manual, Mechanical Drawings section and related Appendices
9. LANL [LIR240-01-01.2](#), Facility Configuration Management

6.0 ATTACHMENTS

Attachment 1, Glossary